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## CLAIMS

- 1        1. A process of forming a semiconductor structure with a relaxed  $Si_{1-y}Ge_y$  layer,  
2 comprising:
  - 3        depositing a graded  $Si_{1-x}Ge_x$  buffer layer on a first substrate, wherein said Ge  
4 concentration x is increased from zero to a value y;
  - 5        depositing a relaxed  $Si_{1-y}Ge_y$  layer;
  - 6        introducing ions into said relaxed  $Si_{1-y}Ge_y$  layer to define a first heterostructure;
  - 7        bonding said first heterostructure to a second substrate to define a second heterostructure;
  - 8        splitting said second heterostructure in the region of the introduced ions, wherein a top  
9 portion of said relaxed  $Si_{1-y}Ge_y$  layer remains on said second substrate.
- 1        2. The process of claim 1 further comprising forming at least one device layer or a  
2 plurality of integrated circuit devices, after said step of depositing said relaxed  $Si_{1-y}Ge_y$  layer.
- 1        3. The process of claim 2, wherein said at least one device layer comprises at least one of  
2 strained Si, strained  $Si_{1-w}Ge_w$  with  $w \neq y$ , strained Ge, GaAs, AlAs, ZnSe and InGaP.
- 1        4. The process of claim 1 further comprising forming an insulating layer before said step  
2 of introducing ions.
- 1        5. The process of claim 1 further comprising planarizing said relaxed  $Si_{1-y}Ge_y$  layer,  
2 before said step of introducing ions.
- 1        6. The process of claim 1, wherein said ions comprise hydrogen  $H^+$  ions or  $H_2^+$  ions.
- 1        7. The process of claim 1 further comprising planarizing said relaxed  $Si_{1-y}Ge_y$  layer, after

2 said step of introducing ions.

1 8. The process of claim 1 further comprising cleaning both said first heterostructure and  
2 said second substrate, before said step of bonding.

1 9. The process of claim 1, wherein said second heterostructure is split by annealing.

1 10. The process of claim 1, wherein said second heterostructure is split by annealing  
2 followed by mechanical force.

1 11. The process of claim 1 further comprising removing the top portion of the remaining  
2 of said relaxed  $Si_{1-y}Ge_y$  layer, after said step of splitting.

1 12. The process of claim 1 further comprising forming at least one device layer, or a  
2 plurality of integrated circuit devices, after said step of splitting.

1 13. The process of claim 12, wherein said at least one device layer comprises at least one  
2 of relaxed  $Si_{1-y}Ge_y$ , strained Si, strained  $Si_{1-w}Ge_w$ , strained Ge, GaAs, AlAs, ZnSe and InGaP.

1 14. The process of claim 1 further comprising re-using the remaining first  
2 heterostructure, after said step of splitting.

1 15. The process of claim 1, wherein said first substrate comprises monocrystalline  
2 silicon.

1 16. A process of forming a semiconductor layer, comprising:  
2 depositing a graded  $Si_{1-x}Ge_x$  buffer layer on a first substrate, said Ge concentration x  
3 being increased from zero to 1;

4           depositing a relaxed Ge layer;

5           forming a monocrystalline semiconductor layer including another material whose lattice

6           constant is approximately close to that of Ge;

7           introducing ions into said semiconductor layer to define a first heterostructure;

8           bonding said first heterostructure to a second substrate to define a second heterostructure;

9           splitting said second heterostructure in the region of introduced ions, wherein a

10          top portion of said semiconductor layer remains on said second substrate.

1           17. The process of claim 16, wherein said semiconductor layer comprises one of GaAs,  
2           AlAs, ZnSe and InGaP.

1           18. The process of claim 16 further comprising forming at least one device layer or a  
2           plurality of integrated circuit devices, after said step of forming said semiconductor layer.

1           19. The process of claim 16 further comprising forming an insulating layer before said  
2           step of introducing ions.

1           20. The process of claim 16 further comprising planarizing said semiconductor layer  
2           before said step of introducing ions.

1           21. The process of claim 16, wherein said ions comprise hydrogen  $H^+$  ions or  $H_2^+$  ions.

1           22. The process of claim 16, further comprising the step of planarizing said  
2           semiconductor layer after said step of introducing ions.

1           23. The process of claim 16 further comprising cleaning both said first heterostructure  
2           and said second substrate, before said step of bonding.

1           24. The process of claim 16, wherein said second heterostructure is split by annealing.

1           25. The process of claim 16, wherein said second heterostructure is split by annealing  
2           and followed by mechanical force.

1           26. The process of claim 16 further comprising removing the top portion of the  
2           remaining of said third semiconductor layer, after said step of splitting.

1           27. The process of claim 16 further comprising forming at least one device layer or a  
2           plurality of integrated circuit devices, after said step of splitting.

1           28. The process of claim 16 further comprising re-using the remaining first  
2           heterostructure, after said step of splitting.

1           29. The process of claim 16, wherein said first substrate comprises monocrystalline  
2           silicon.

1           30. A process of forming a semiconductor structure with a relaxed  $Si_{1-z}Ge_z$  layer,  
2           comprising:

3           depositing a graded  $Si_{1-x}Ge_x$  buffer layer on a first substrate, said Ge concentration x  
4           being increased from zero to a selected value y, and y being less than 0.2;  
5           depositing a relaxed  $Si_{1-z}Ge_z$  layer, where z is between 0.2 and 0.25;  
6           introducing ions into said graded  $Si_{1-x}Ge_x$  buffer layer to define a first heterostructure;  
7           bonding said first heterostructure to a second substrate to define a second heterostructure;  
8           splitting said second heterostructure in the region of introduced ions, wherein the upper  
9           portion of first graded  $Si_{1-x}Ge_x$  layer and said relaxed  $Si_{1-z}Ge_z$  layer remains on said second

10. substrate; and

11. selectively etching the remaining portion of said graded  $Si_{1-x}Ge_x$  layer, wherein  
12. said relaxed  $Si_{1-z}Ge_z$  layer remains on said second substrate.

1. 31. The process of claim 30 further comprising forming at least one device layer or a  
2. plurality of integrated circuit devices, after said step of forming said relaxed  $Si_{1-z}Ge_z$  layer.

1. 32. The process of claim 31, wherein said at least one device layer includes one or more  
2. of strained Si, strained  $Si_{1-w}Ge_w$  with  $w \neq z$ , and strained Ge.

1. 33. The process of claim 30 further comprising forming an insulating layer before said  
2. step of introducing ions.

1. 34. The process of claim 30 further comprising planarizing said relaxed  $Si_{1-z}Ge_z$  layer  
2. before said step of introducing ions.

1. 35. The process of claim 30, wherein said ions comprise hydrogen  $H^+$  ions or  $H_2^+$  ions.

1. 36. The process of claim 30 further comprising planarizing the relaxed  $Si_{1-z}Ge_z$  layer  
2. after said step of introducing ions.

1. 37. The process of claim 30 further comprising cleaning both said first heterostructure  
2. and said second substrate, before said step of bonding.

1. 38. The process of claim 30, wherein said second heterostructure is split by annealing.

1. 39. The process of claim 30 further comprising planarizing said second relaxed  $Si_{1-z}Ge_z$   
2. layer after said step of etching.

1           40. The process of claim 30 further comprising forming at least one device layer or a  
2       plurality of integrated circuit devices, after said step of etching.

1           41. A process of forming a semiconductor layer, comprising:  
2       depositing a graded  $Si_{1-x}Ge_x$  buffer layer on a first substrate, said Ge concentration x  
3       being increased from zero to a value y;  
4       depositing a relaxed  $Si_{1-y}Ge_y$  layer;  
5       depositing a strained or defect layer;  
6       depositing a relaxed layer;  
7       introducing ions into said strained or defect layer to define a first heterostructure;  
8       bonding said first heterostructure to a second substrate to define a second heterostructure;

9       and

10           splitting said second heterostructure in the region of the strained or defect layer,  
11       wherein said relaxed layer remains on said second substrate.

1           42. The process of claim 41, wherein said strained or defect layer comprises either a  
2       strained  $Si_{1-z}Ge_z$  layer with  $z \neq y$ , or other III-V material.

1           43. The process of claim 41, wherein said relaxed layer or said strained or defect layer  
2       comprises either a relaxed  $Si_{1-w}Ge_w$  layer where w is close or equal to y, or, when y is equal to 1,  
3       one of Ge, GaAs, AlAs, ZnSe and InGaP.

1           44. The process of claim 41 further comprising forming at least one device layer or a  
2       plurality of integrated circuit devices, after said step of depositing said relaxed layer.

1        45. The process of claim 41 further comprising forming an insulating layer before said  
2    step of introducing ions.

1        46. The process of claim 41 further comprising planarizing said relaxed layer before said  
2    step of introducing ions.

1        47. The process of claim 41, wherein said ions comprise hydrogen  $H^+$  ions or  $H_2^+$  ions.

1        48. The process of claim 41 further comprising planarizing said relaxed layer after said  
2    step of introducing ions.

1        49. The process of claim 41 further comprising cleaning both said first heterostructure  
2    and said second substrate, before said step of bonding.

1        50. The process of claim 41, wherein said second heterostructure is split by annealing.

1        51. The process of claim 41 further comprising removing one of any remaining of said  
2    strained or defect layer, and the top portion of said relaxed layer, after said step of splitting.

1        52. The process of claim 41 further comprising forming at least one device layer or a  
2    plurality of integrated circuit devices, after said step of splitting.

1        53. The process of claim 41 further comprising re-using the remaining first  
2    heterostructure for a subsequent process after planarizing.

1        54. A semiconductor structure comprising:  
2        a first semiconductor substrate;  
3        a second layer of relaxed  $Si_{1-x}Ge_x$ , wherein  $x = 0.1$  to 1; and

4           a third layer comprising at least one of GaAs, AlAs, ZnSe and InGaP, or strained  $Si_{1-y}Ge_y$   
5        wherein  $y \neq x$ .

1           55. A semiconductor structure comprising:

2           a first substrate comprising monocrystalline silicon substrate;  
3           a second layer of graded  $Si_{1-x}Ge_x$  buffer layer, wherein said Ge concentration x is  
4        increased from zero to a value y;  
5           a third layer of relaxed  $Si_{1-y}Ge_y$  ;  
6           a fourth strained or defect layer comprising either a strained  $Si_{1-z}Ge_z$  layer with  $z \neq y$ , or  
7        other III-V or II-VI material; and  
8           a fifth relaxed layer comprising either a relaxed  $Si_{1-w}Ge_w$  layer where w is close or equal  
9        to y, or, when y is equal to 1, at least one of Ge, GaAs, AlAs, ZnSe and InGaP.